BHARATHIDASAN UNIVERSITY

Program: M.Sc., Biomedical Science

Course Title : Neurobiology

Neural tube form the 5 major divisions of the CNS

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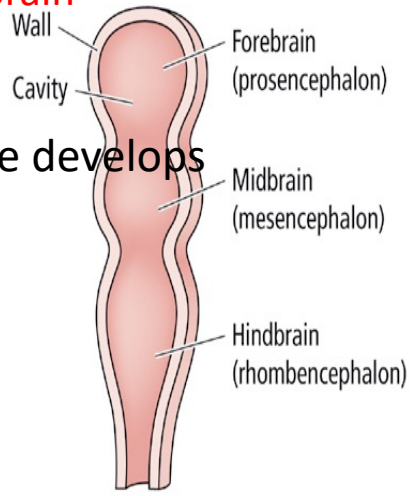
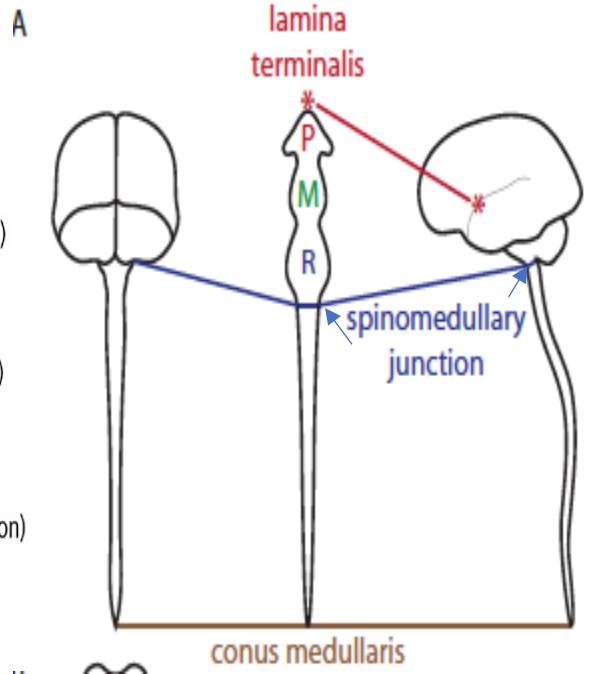
Neural tube form the 5 major divisions of the CNS

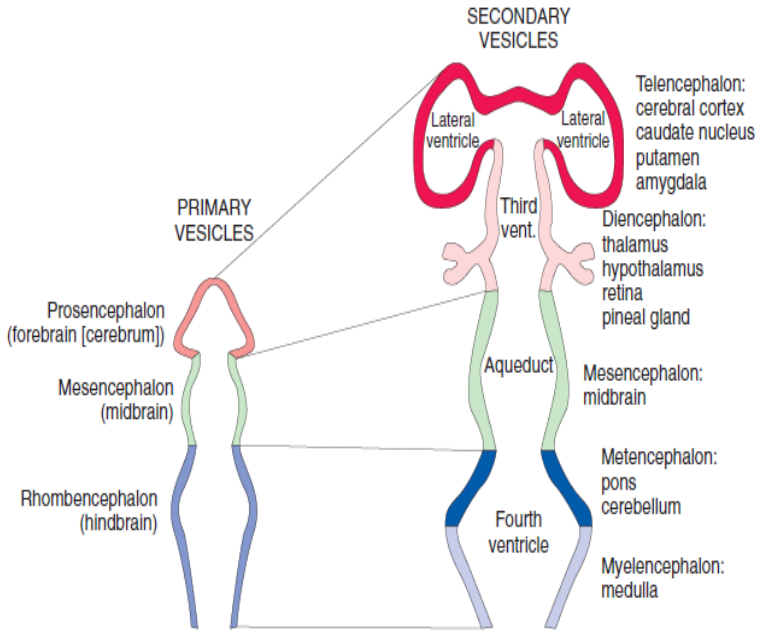
- After neurulation, the neural tube reaches from a caudal point, conus medullaris, or caudal end of the spinal cord, rostrally to the lamina terminalis, the rostral end of the neural tube.
- Lamina terminalis becomes buried within the cerebrum
- At the end of the 4th gestational week
    - neural tube contains single layer of columnar cells called **neuroepithelial cells** proliferate and form a thickened tubular structure, cephalic (rostral) end begins to form 3 enlargements
        1. Prosencephalon or forebrain
        2. Mesencephalon or midbrain
        3. Rhombencephalon or hindbrain

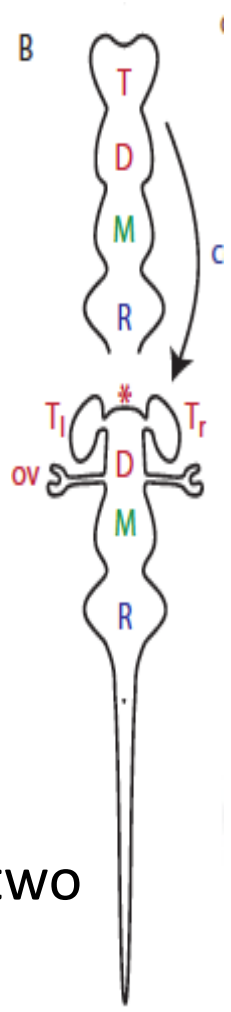




- The most caudal portion of the neural tube develops into the spinal cord.

- At the 5th week of gestation: prosencephalon divides into the telencephalon and the diencephalon





- telencephalic vesicle invaginates at the midline to become two telencephalic hemispheres
- the **telencephalon** with its two lateral swellings, the future cerebral hemispheres

Telencephalon & diencephalon

- telencephalon gives rise to:

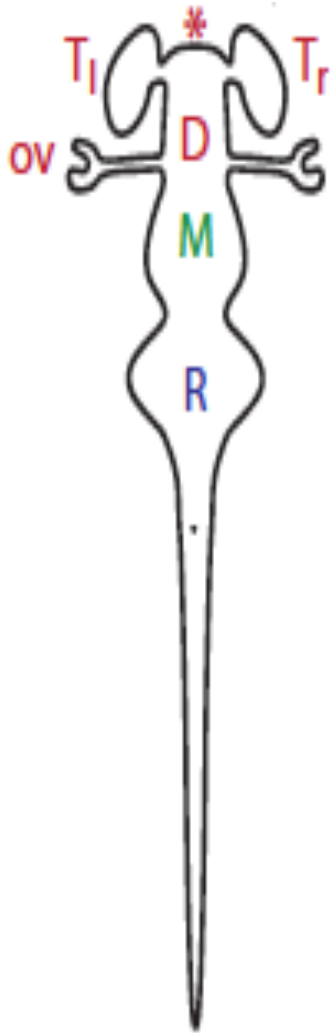
1. both hemispheres of cerebral cortex,
2. the core components of the basal ganglia, and
3. the amygdala .

- diencephalon gives rise to

1. the thalamus and
2. hypothalamus and
3. two outpouchings called the optic vesicles

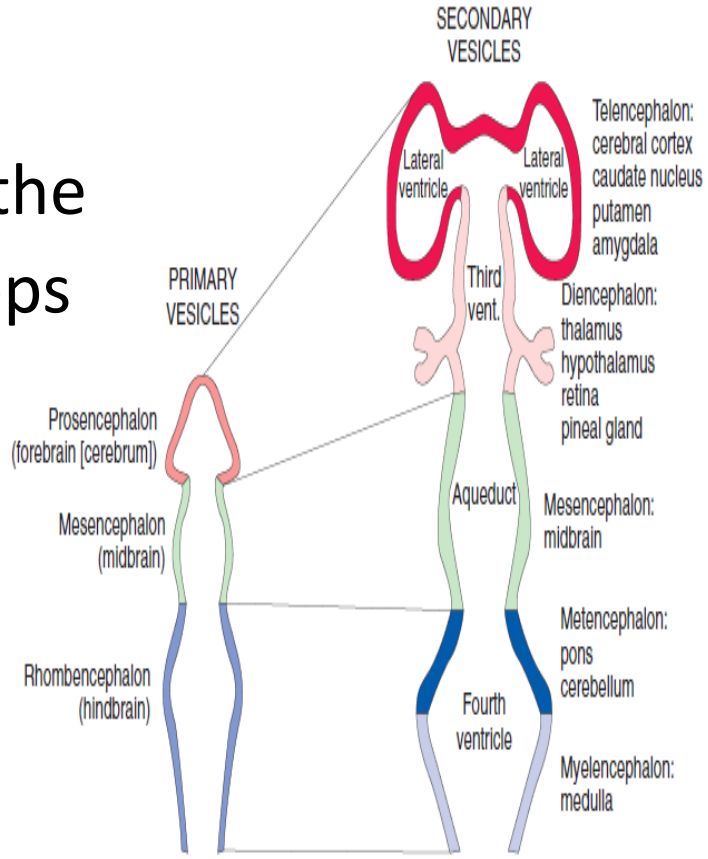
- The stalk of the optic vesicles becomes the optic nerve, and

the cup at the end of the outpouching becomes the retina



Rhombencephalon

- The rhombencephalon divides into the Metencephalon and the myelencephalon into the adult pons, medulla, and cerebellum
- The anterior third of the hindbrain (Metencephalon) gives rise to the
    1. pons and
    2. cerebellum,
- whereas the posterior portion of the hindbrain (myelencephalon) develops into the
    1. medulla.



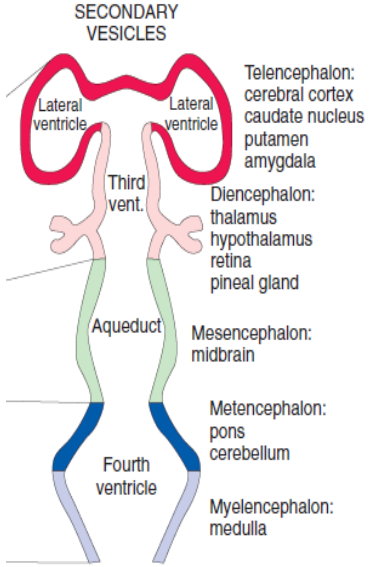
By the end of the 5th week

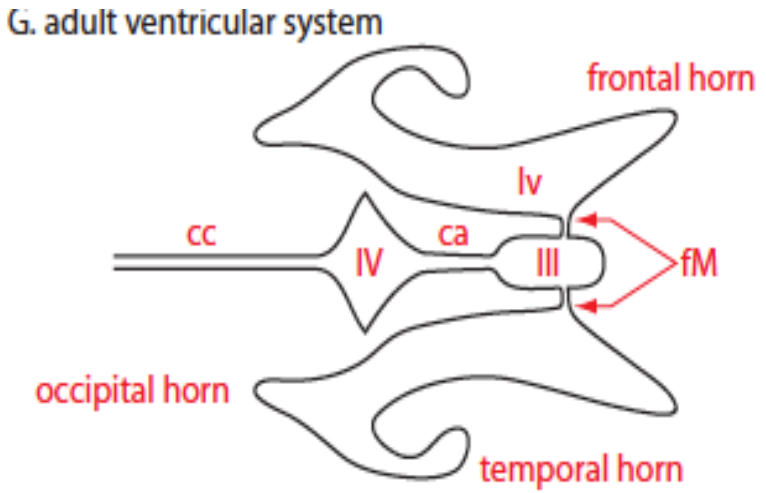
- the embryonic human brain contains 4 vesicles. From rostral to caudal:
  1. Telencephalon ≈ cerebral cortex, basal ganglia, amygdala
  2. Diencephalon ≈ thalamus, hypothalamus, retina
  3. Mesencephalon = midbrain
  4. Rhombencephalon = hindbrain = pons, medulla, and cerebellum
- The 5th major structure is
  5. Spinal cord

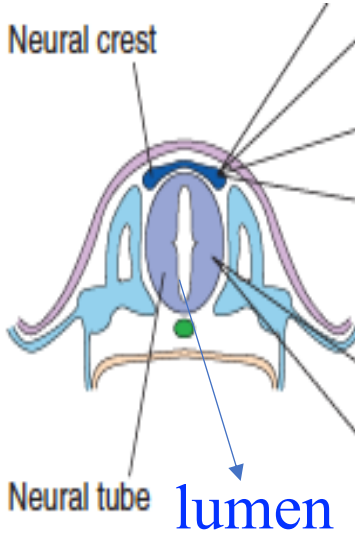
- The spinal cord and the four regions of the brain comprise the five divisions of the CNS

Ventricular system developed from lumen of n. tube

- The embryonic lumen expands, bulges, and cinches along with corresponding changes in the shape of the neural tube and eventually develops into the cerebrospinal fluid (CSF)-filled ventricular system
- The lumen of the developing CNS is subdivided into the ventricles of the brain and the central canal of the spinal cord.
- The **lateral ventricles** of the cerebral hemispheres communicate with the **third ventricle** of the diencephalon via the **interventricular foramina** (of Monro). The **fourth ventricle**, located in the rhombencephalon, communicates with the third ventricle via the **cerebral aqueduct** (of Sylvius) located in the mesencephalon.
- The spinal cord surrounds a central lumen called the central canal.







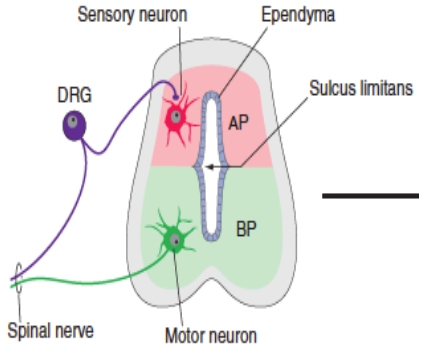
Developmental territories confer a basic functional organization

- each division of the CNS is with different functions, arise from different embryonic territories
- In the embryonic cord, the central lumen has bilateral inflection points or indentations termed the sulcus limitans.
- sulcus limitans separates the embryonic spinal cord into dorsal and

ventral halves:

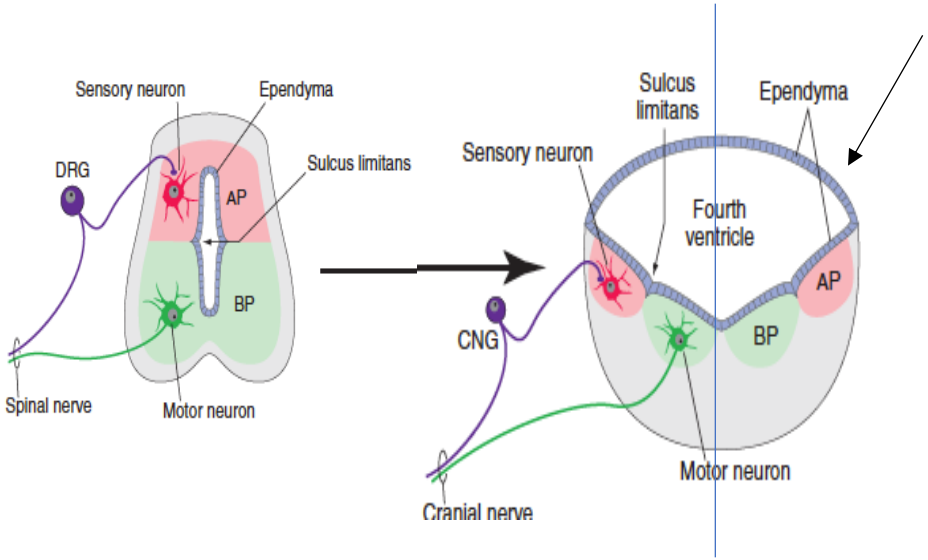
1. Dorsal half- Alar plate- serve sensory functions,
2. Ventral half- Basal plate- serve motor functions

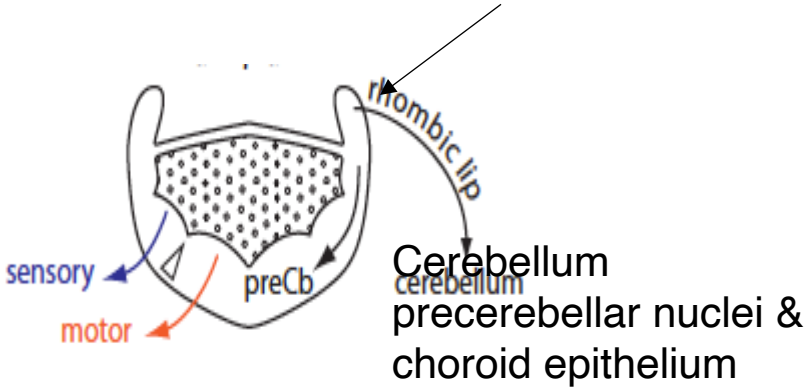
- Sensory afferents enter the spinal cord from the dorsal side and terminate in the dorsal part of the spinal gray matter.
- Motoneurons (efferent) innervating skeletal muscles have somata in the ventral portion of the spinal gray and send an axon out from the ventral spinal surface.



4^{th} ventricle- Hindbrain

- neural tube opens up in the hindbrain as the fourth ventricle replaces the central canal
- sulcus limitans is still visible in the hindbrain.
- Further, the sulcus limitans in the hindbrain still separates AP & BP.
- Only difference is that AP is now in lateral & BP is now in medial.
- Cells that border the hindbrain roof plate form the rhombic lip

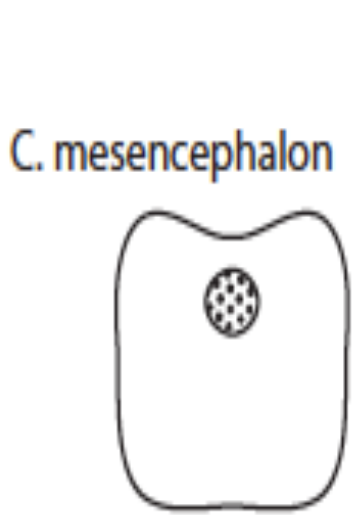


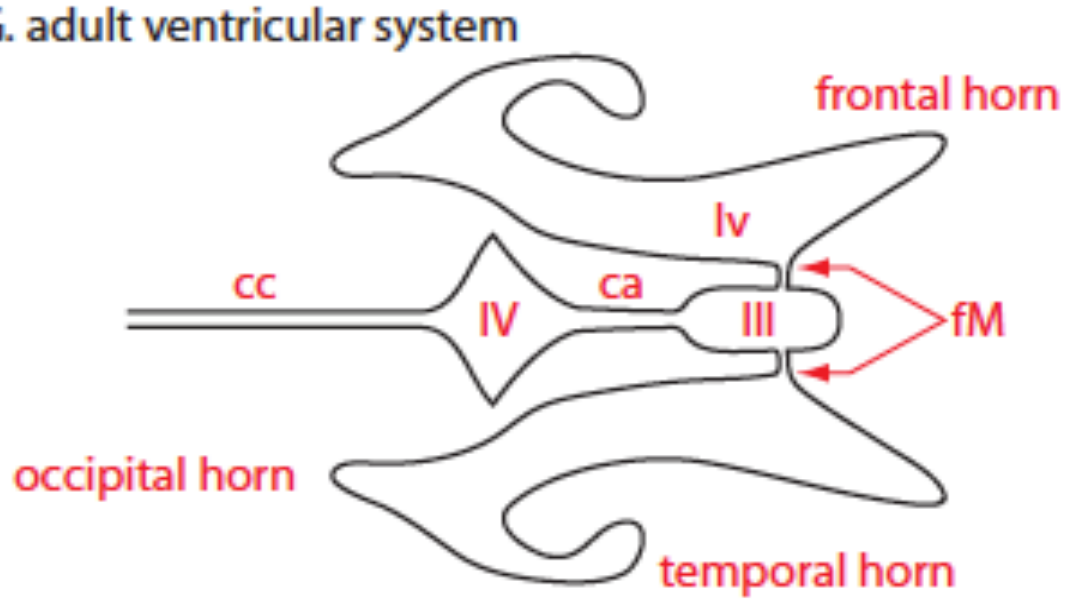


Cerebellum
precerebellar nuclei &
choroid epithelium

- fourth ventricle occupies the space between the medulla and pons ventrally and the cerebellum dorsally
- If we remove the cerebellum and viewed the fourth ventricle from above,

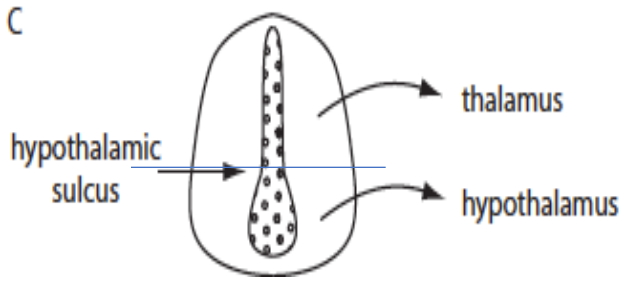
we would see a depression, or fossa , shaped like a diamond or rhombus

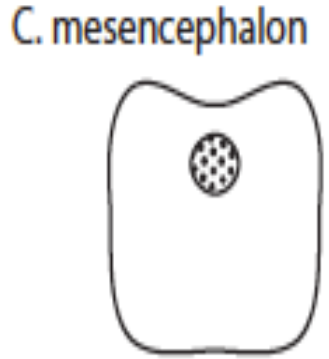




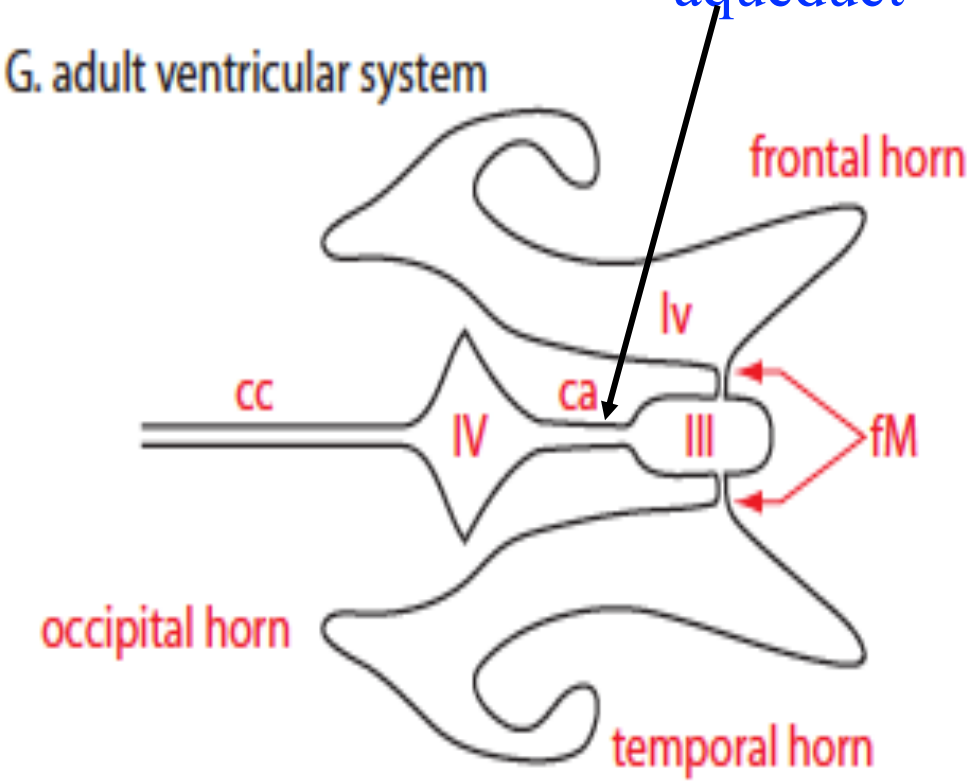
cerebral aqueduct-embryonic midbrain

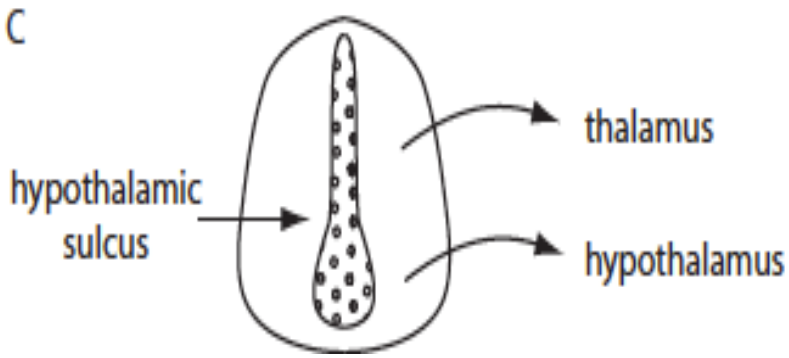
1. At the junction of the rhombencephalon and mesencephalon, the fourth ventricle narrows into a thin channel.
2. This channel, present in the midbrain only, is called the cerebral aqueduct .
3. the inflection point in, a transverse groove in the wall of the lumen corresponds to the hypothalamic sulcus
4. cells in dorsal to the hypothalamic sulcus, are become the thalamus, also called dorsal thalamus , and
5. cells in ventral to the sulcus, give rise to the hypothalamus.
6. The habenular nuclei and the pineal body form the epithalamus.





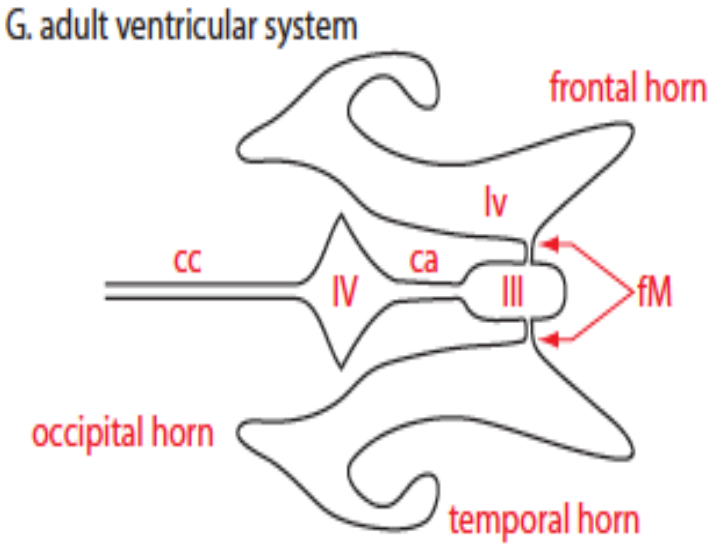
This channel, present in the midbrain only, is called the cerebral aqueduct

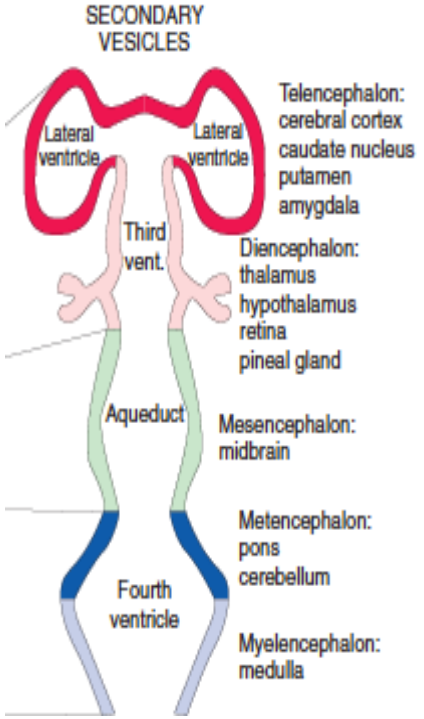


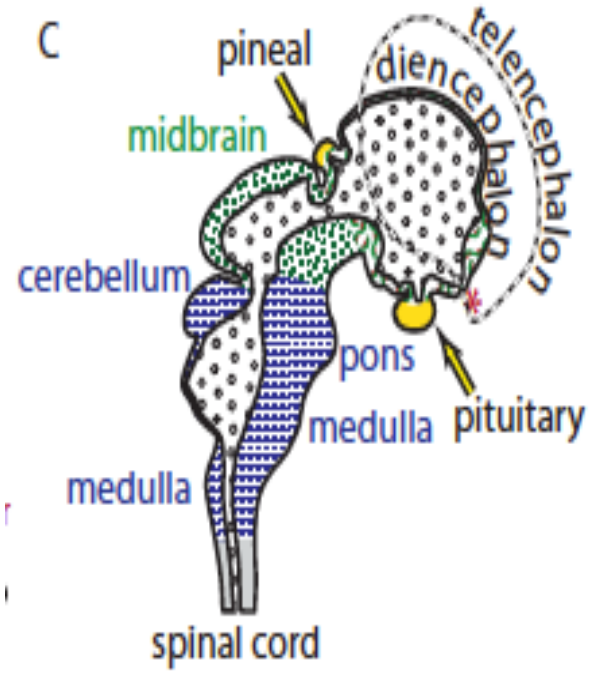


The narrow cerebral aqueduct links the fourth ventricle to the third ventricle present on the midline of the diencephalon.

3rd ventricle-diencephalon.



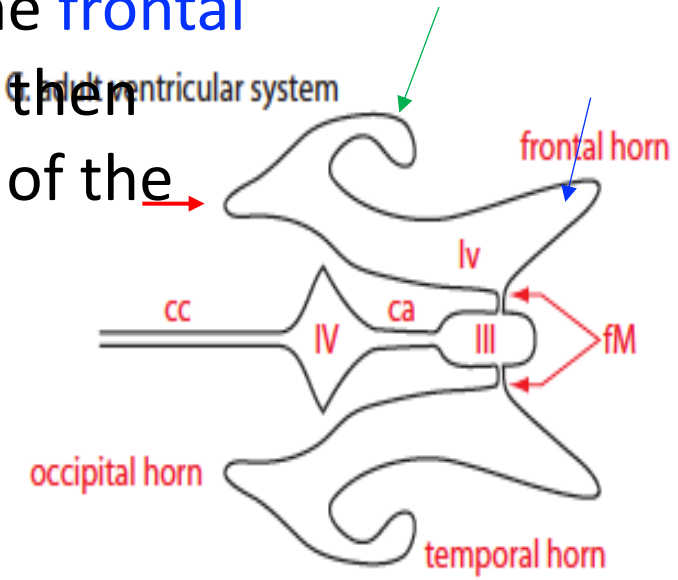


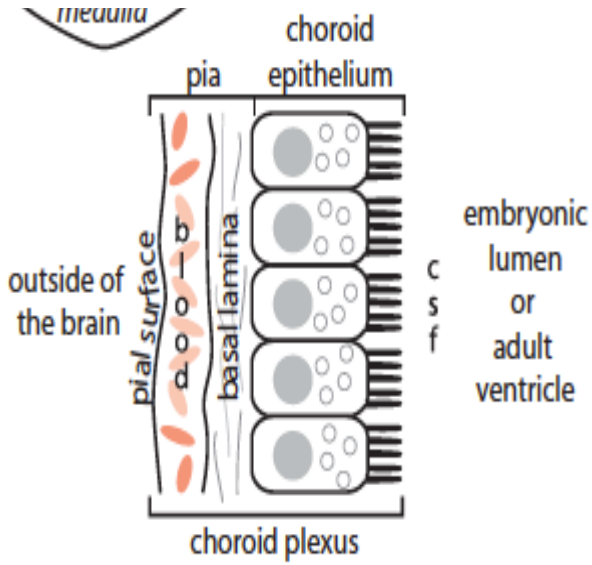


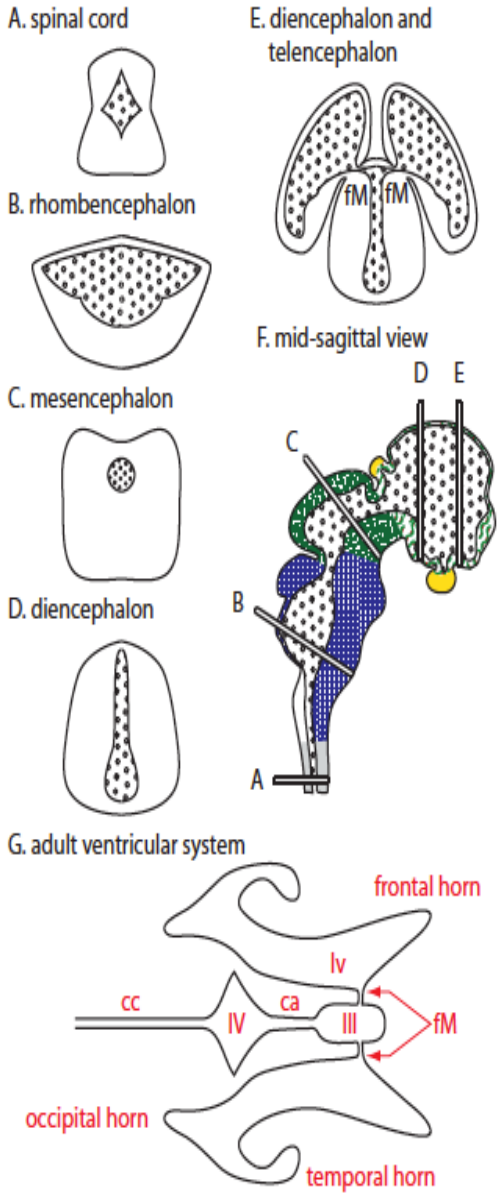
- cerebral aqueduct links the fourth ventricle to the third ventricle present on the midline of the diencephalon.

lateral ventricle- telencephalon

- telencephalic vesicle invaginates to form two dorsal telencephalic halves or hemispheres , which will eventually develop into the two cerebral hemispheres
- each hemisphere has its own lumen, which develops into a lateral ventricle
- These two lateral ventricles will communicate with each other as well as with the third ventricle through a short, narrow strait called the foramen of Monro or the interventricular foramen.
- lateral ventricles extend rostrally into the frontal lobe, caudally into the occipital lobe, and then curve around and pass through to the tip of the temporal lobe



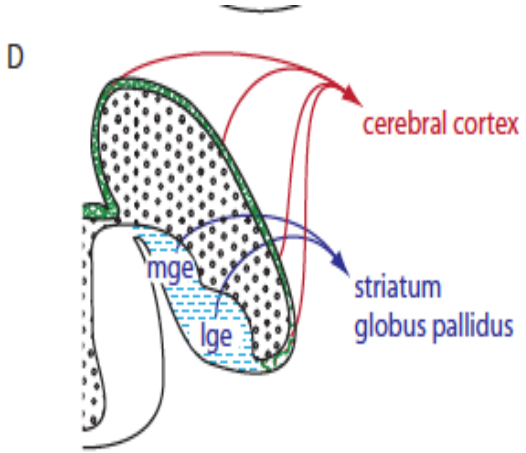

medulla
choroid
pia
epithelium
outside of
the brain
pial surface
basal lamina
csf
embryonic
lumen
or
adult
ventricle
choroid plexus


A. spinal cord
E. diencephalon and
telencephalon
fM
fM
B. rhombencephalon
F. mid-sagittal view
D E
C. mesencephalon
C
B
D. diencephalon
A
G. adult ventricular system
frontal horn
lv
cc
ca
IV
III
fM
occipital horn
temporal horn

embryonic telencephalon

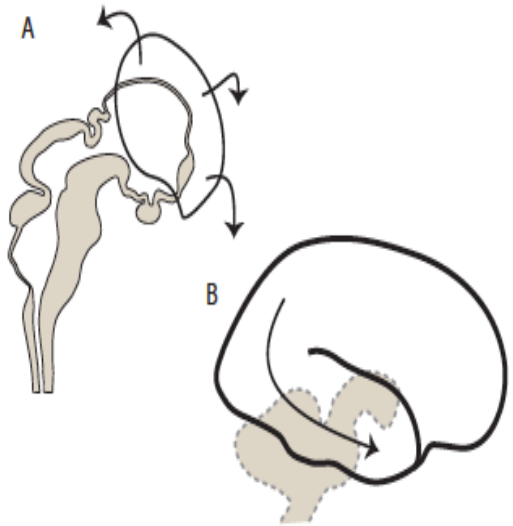
- has distinct dorsal and ventral territories
- a thin rind of tissue in dorsal become the cerebral cortex.
- Ventral tissue is amassed into bulges called ganglionic eminences.
- In the ganglionic eminences, the medial and lateral eminences becomes striatum and pallidum respectively,
- these two core structures is part of the

basal ganglia.



telencephalon

1. proliferation of telencephalic progenitor cells produces an enormous number of neurons, counted in the billions.
2. To accommodate all of the cells produced, the territory of the human cortex is greatly expanded.
3. expansion takes the form of the cortex growing caudally back over the thalamus and brainstem
4. dorsal telencephalic tissue expands so much that the cerebral cortex covers the diencephalon, midbrain, and part of the hindbrain,
5. the cortex populates a bulge of tissue that curves around to form the temporal lobe
6. quintessentially human functions such as complex verbal communication, face recognition, and factual memory are served by Temporal lobe.



Protection and nourishment of the brain

- Due to the delicate nature, in the CNS tissue, the fact is damaged nerve cells cannot be replaced, makes it irreplaceable tissue be well protected.
- Four major features help protect the CNS from injuries:
  i. It is enclosed by bony structure. The cranium or skull encases the brain in case of spinal cord, vertebral column surrounds it.
  ii. Three protecting and nourishing membranes called meninges lie between bony structure and CNS tissue
  iii. Highly selective blood brain barrier limits the access of blood borne materials into the vulnerable CNS tissue.
  iv. The CNS “floats” in a special cushioning fluid known as cerebrospinal fluid (CSF)